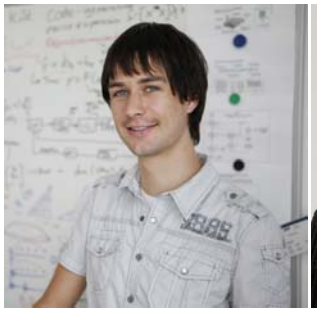
The collaborative engineer

Erwin Moerland, Björn Nagel
DLR, Institute of Air Transportation Systems, Hamburg, Germany

The collaborative engineer

How education can bring forth the next generation of engineers



Erwin Moerland

Björn Nagel

Background in education

Researchers

German Aerospace Center in Hamburg

Course

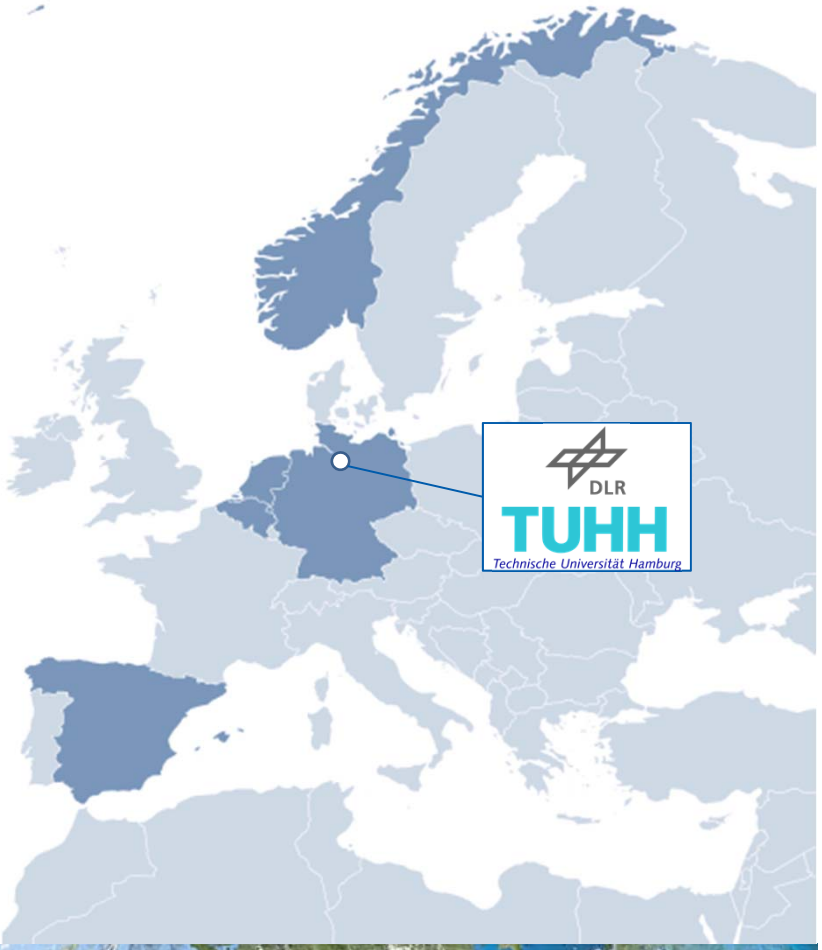
aircraft design II (4 lecturers)

Course contents

aerodynamics, structures, aeroelastic coupling, performance, optimization

Exercise

students program their own aeroelastically coupled wing sizing routine and apply to realistic wing analyses

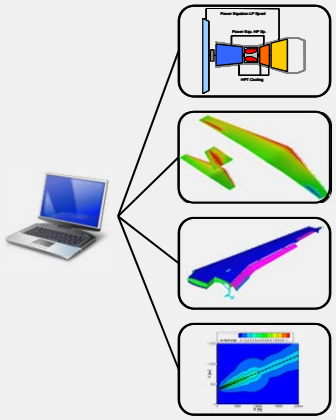


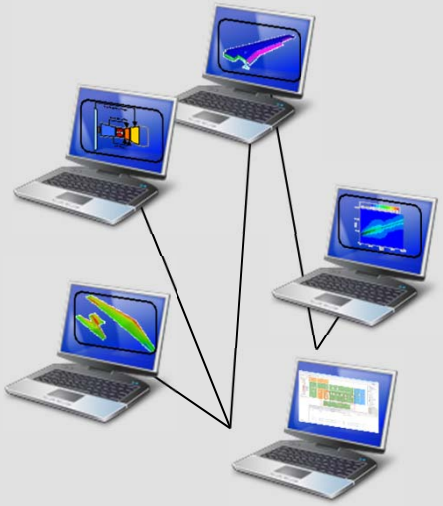
DLR

Development in design methods

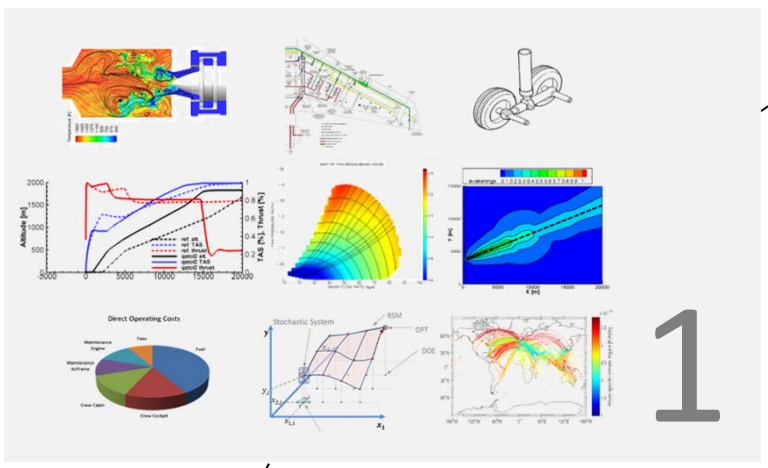
trends in multidisciplinary design optimisation (MDO)

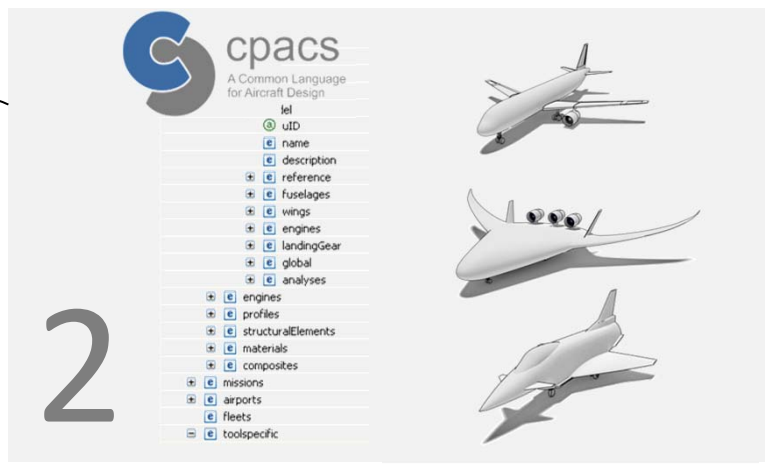
1st generation	2nd generation	3rd generation
analysis-based design computations	Workflow management	?

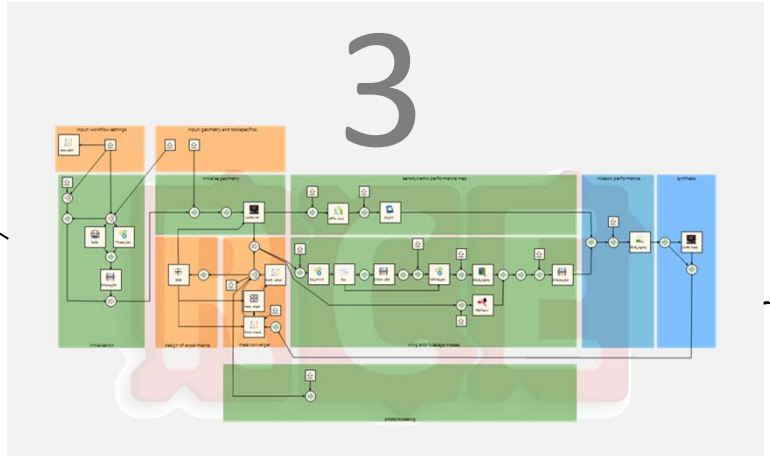


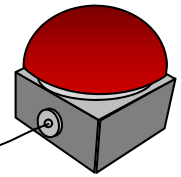


MDO: main ingredients

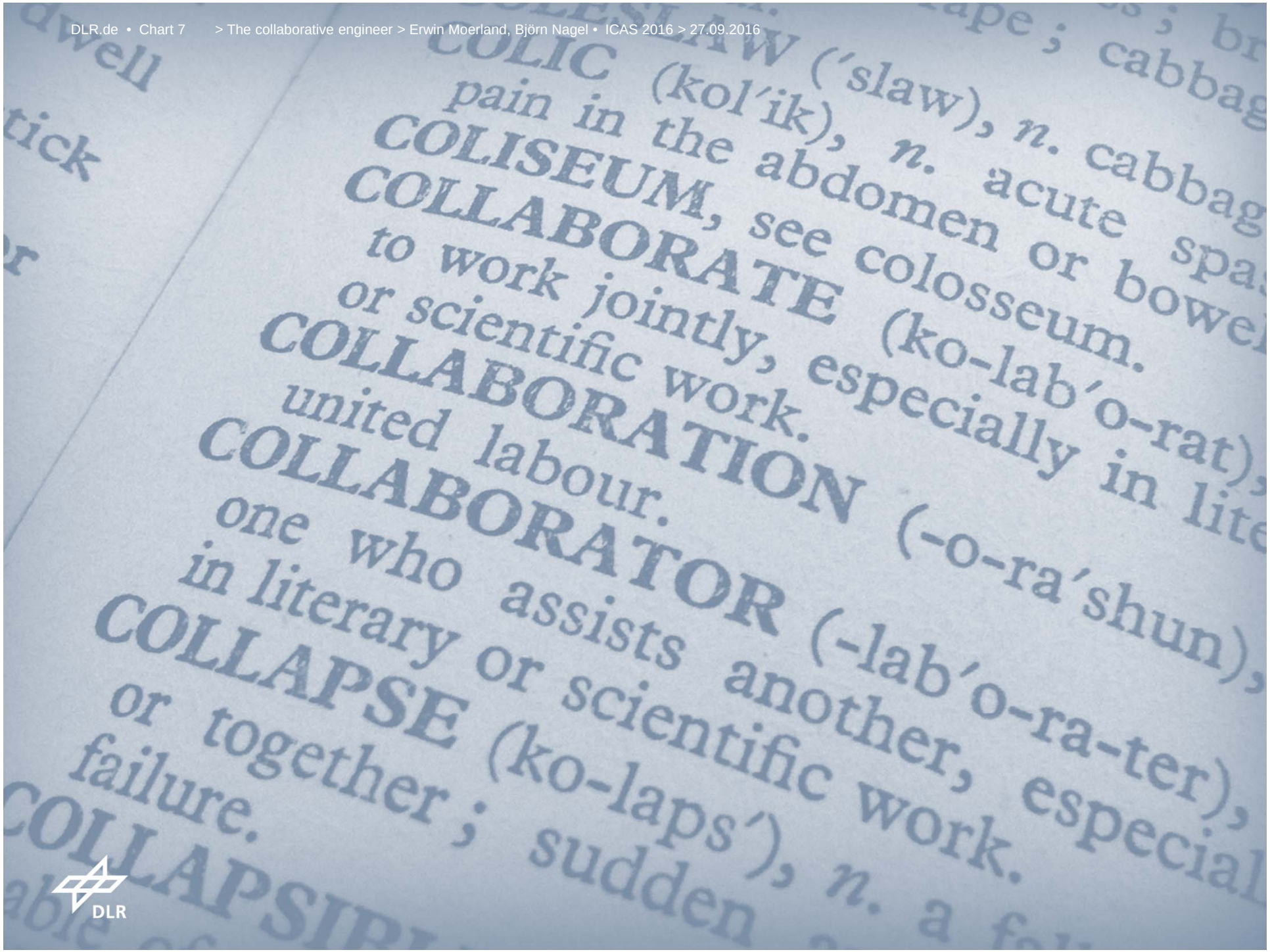




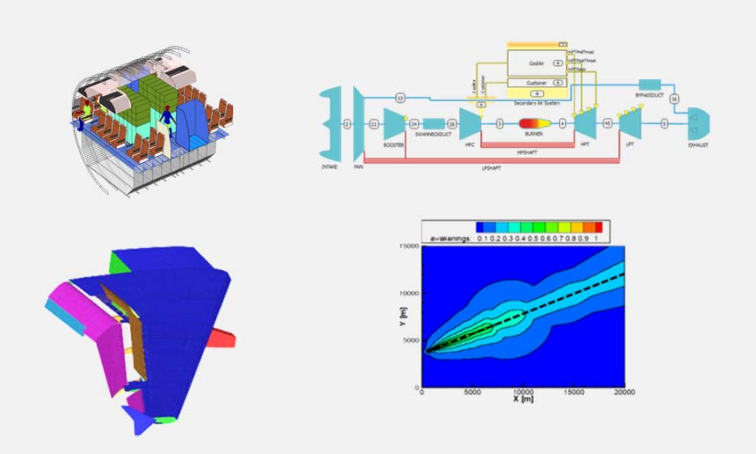


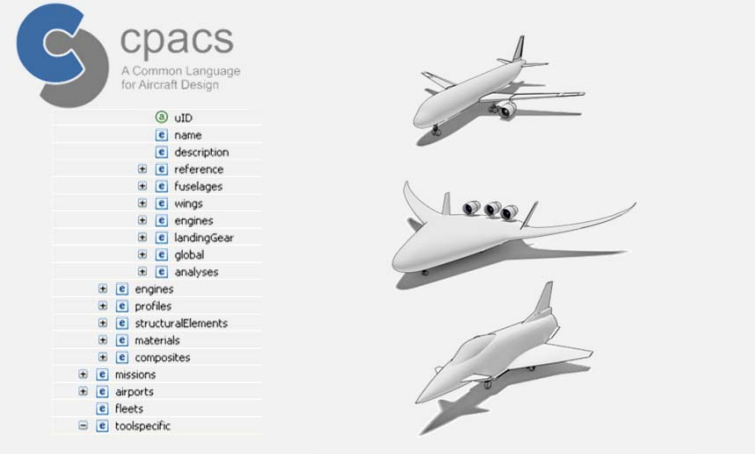


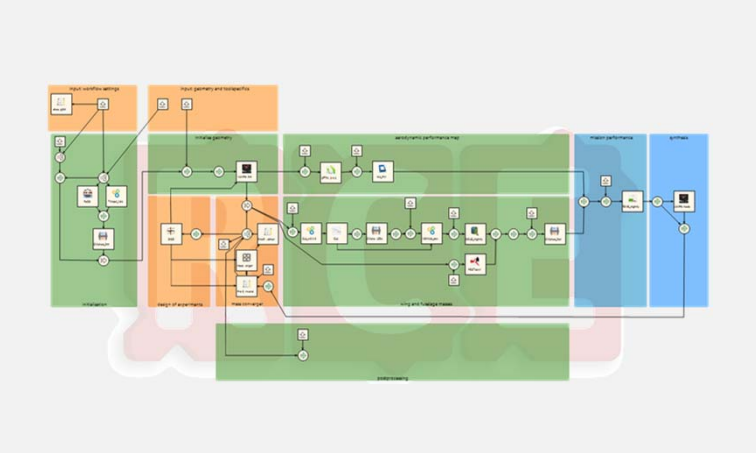
“having tools” does not mean *“having skills”*

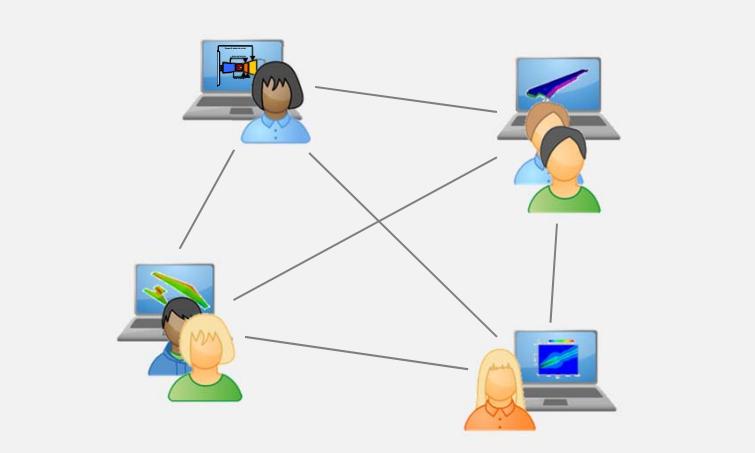

COLESLAW ('slaw), n. cabbag
COLIC (kol'ik), n. acute spas
pain in the abdomen or bowe
COLISEUM, see colosseum.
COLLABORATE (ko-lab'o-rat),
to work jointly, especially in lite
or scientific work.
COLLABORATION (-o-ra'shun),
united labour.
COLLABORATOR (-lab'o-ra-ter),
one who assists another, especial
in literary or scientific work.
COLLAPSE (ko-laps'), n. a
or together; sudden
failure.
COLLAPSIB

Collaborative design in MDO: ingredients



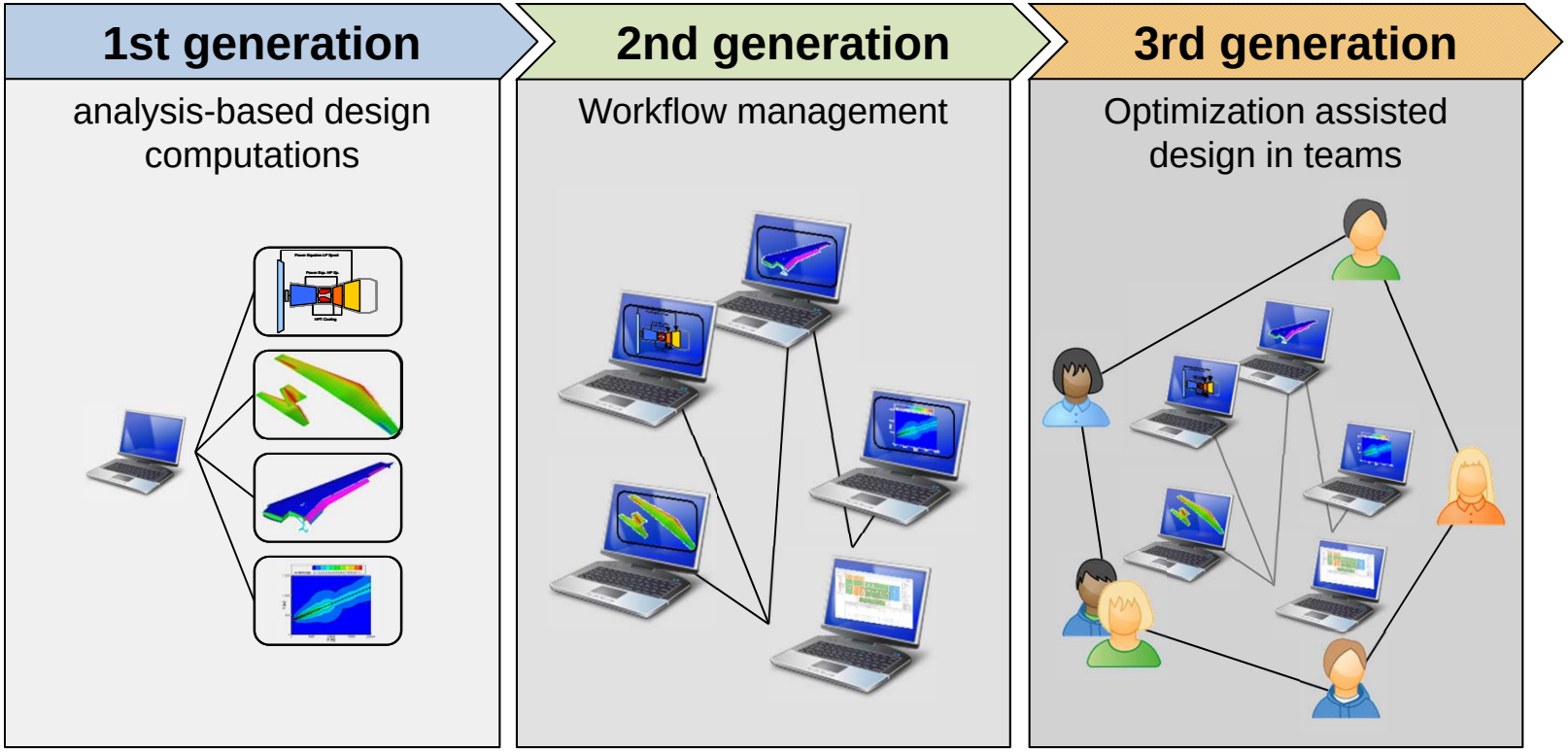




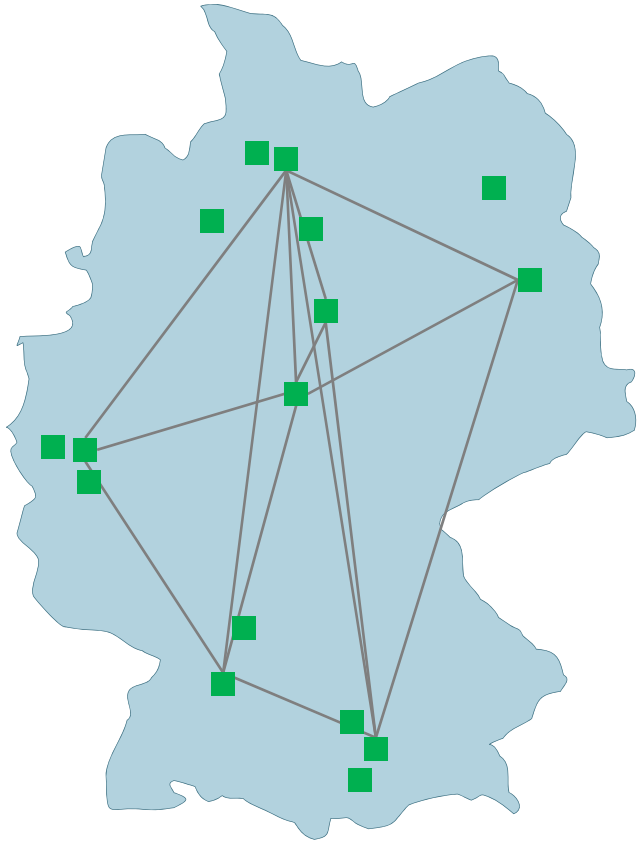


Development in design methods

trends in multidisciplinary design optimisation (MDO)



Collaborative design at DLR



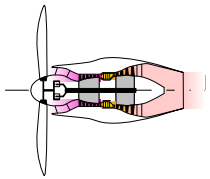
Disciplinary expertise distributed across DLR

Aerodynamics & flow technology	Aero elasticity
Propulsion technology	Structures and design
Composite structures	Flight guidance
Flight systems	System dynamics & control
Simul.- and software technology	Engineering facility
Air transportation systems	

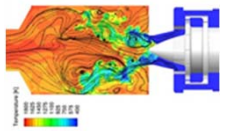
Example:
strut-braced wing design project FrEACt

Collaborative design at DLR: integrating all disciplines

DLR-AT

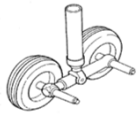


DLR-VT

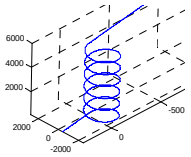


DLR-FT

DLR-AE



DLR-SR



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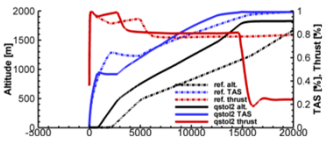

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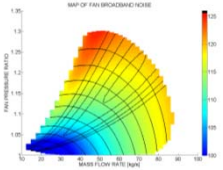
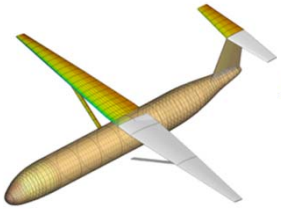
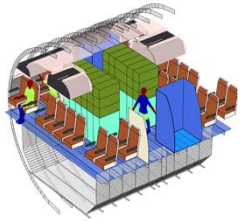




DLR-AS



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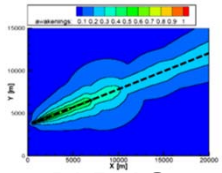

DLR-AS

DLR-AS

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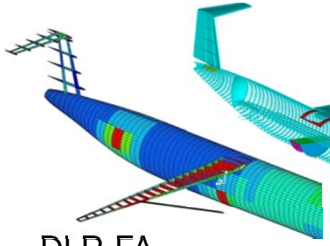

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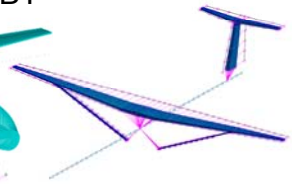
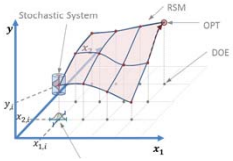


DLR-FA

DLR-AE



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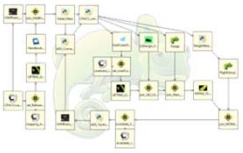
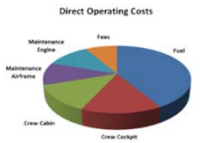


DLR-SC



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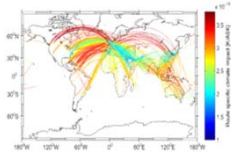
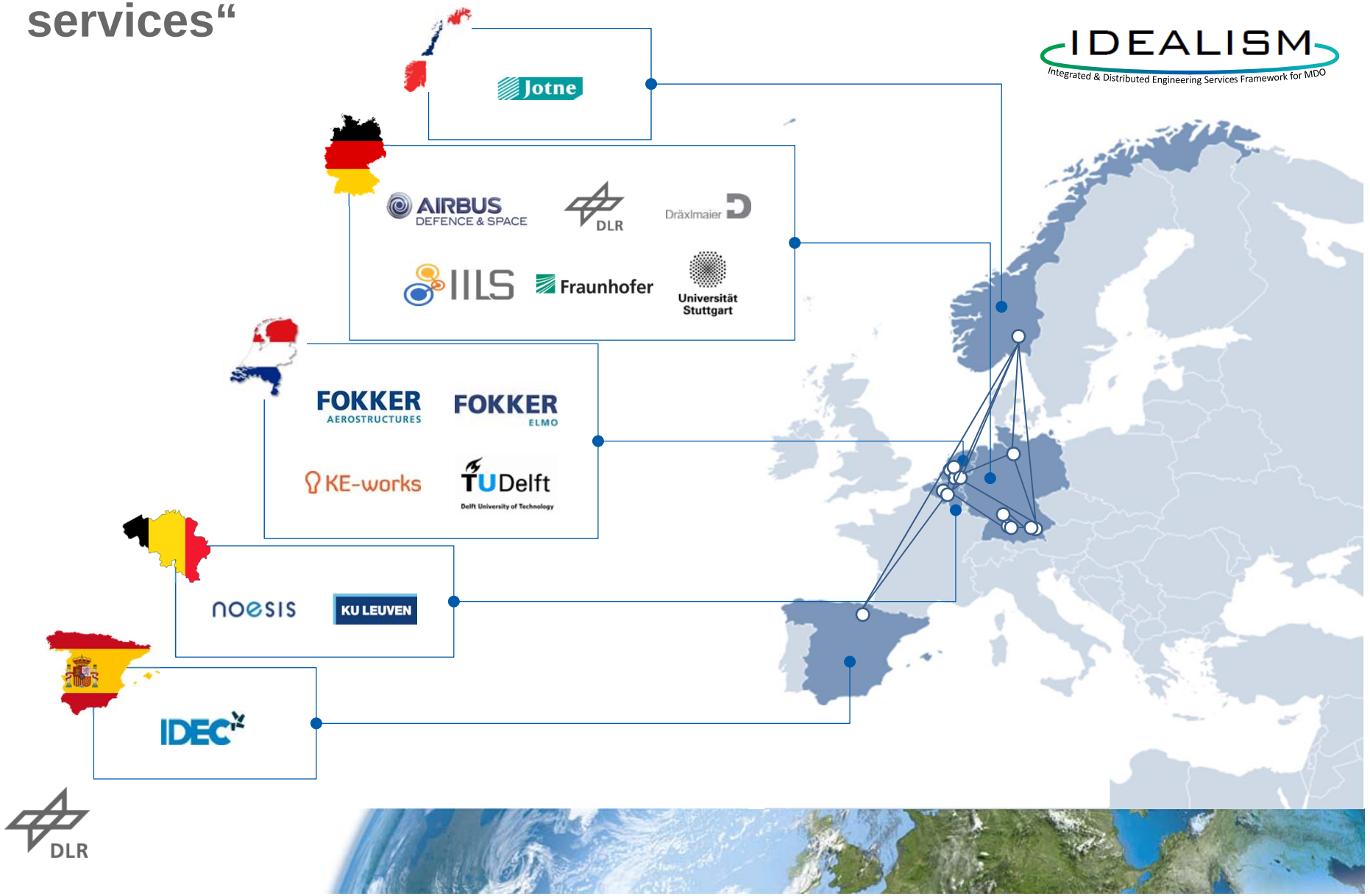


DLR-PA,
DLR-LY

Strut-braced wing design project „FrEACs“: 20 departments of DLR

source: Björn Nagel, DLR-LY

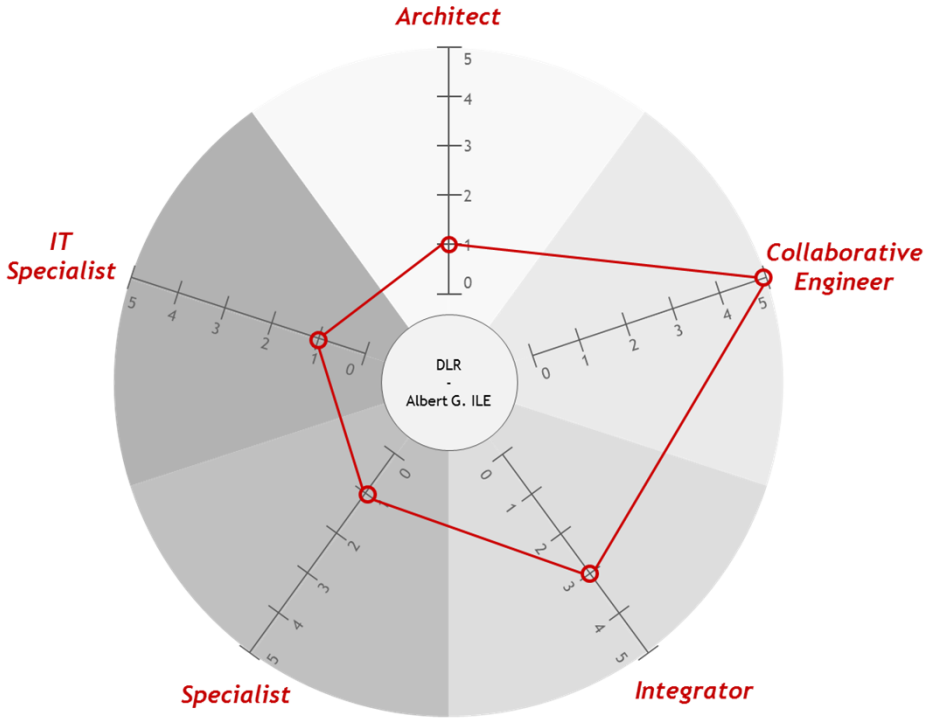
EU-wide project on collaboration using „engineering services“



EU-wide(+) project on cross-organisational collaboration

AGILE
AIRCRAFT 3RD GENERATION MDO FOR INNOVATIVE COLLABORATION OF HETEROGENEOUS TEAMS OF EXPERTS

Roles in the collaborative design process



Role	Description	Analogy
Architect	define and formalize the aircraft design task and process	composer
Collaborative engineer	make competences accessible across partners	philharmony / orchestra
Integrator	formulate optimization strategy formalize the MDO process	director
Disciplinary Specialist	provide disciplinary design capabilities	solo musicians
IT specialist	provide infrastructure for tool execution and data exchange	auditorium

source: AGILE

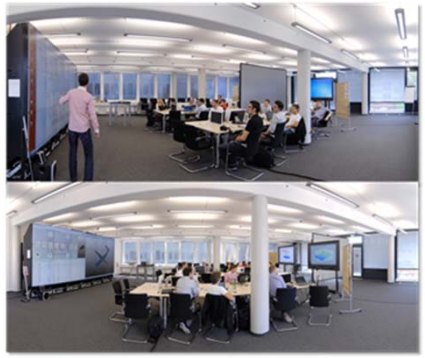
See also ICAS 2016_0563: „Towards the 3rd generation MDO collaborative environment, P.D. Ciampa

Working methods change

<u>Design Camps</u>

2-3 day intensive gathering of team participants

- focus:
  - executing analyses
  - collaborative interpretation of dependencies and results
  - intensifying cross-disciplinary interactions
- to be avoided:
  - bugs
- connected status meeting or report to disseminate results „hot from the press“



	OAD knowledge →	knowledge detail →
architects		1-2
integrators		1-2
specialists		≥ 5
collaborative engineer		
IT specialist		# persons involved

HOWEVER

Not regularly implemented in industry

Industry does not regularly apply collaborative design methods based on MDO

- established engineers are:

  afraid
  to step out of their „comfort zone“

  reluctant
  to thrust results of others: „not invented here syndrome“

  do not like
  being imposed predefined working methods

Even engineers in research think too technically

#	Issue	score
1	smooth cross-organizational workflow execution	1.2
2	tool availability	1.6
3	shielding of trade secrets	1.7
4	clearly defined input/output	1.9
5	clear interfaces	2.0
6	completed input / output definition	2.0
7	computational infrastructure + data security location	2.0
8	implementation cross-organizational knowledge base	2.0
9	regulated exchange of IP	2.1
10	batch executability of tools	2.4
11	proper (human) communication	2.5
12	computational power	2.5
13	knowledge on which MDO architecture to apply	2.6
14	result reproducibility	2.8
15	tools applicability (boundaries)	2.8

preliminary results

source: questionnaire among engineers involved in collaborative design projects, lower scores indicate larger barrier

the current engineer *underestimates* non-technical barriers to collaboration

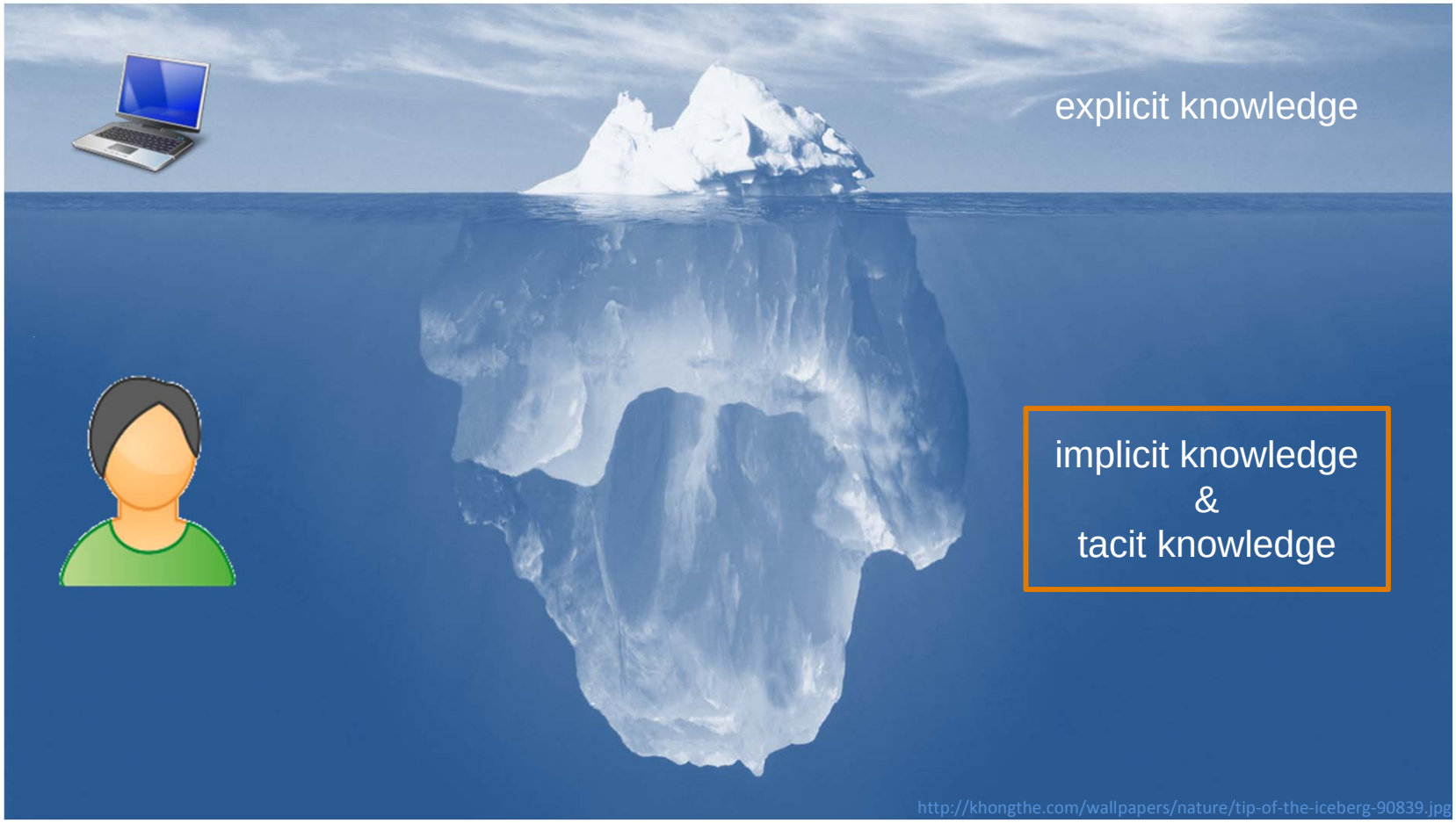
confirmed by Belie (2002): „Non-Technical Barriers to Multidisciplinary Optimization in the Aerospace Industry"
http://arc.aiaa.org/doi/abs/10.2514/6.2002-5439

What education can do…

For students pursuing a career in aerospace engineering:

- Let them „taste“ the roles in novel design approaches
- Let them „see“ that collaboration is key
- Let them „feel“ responsibility, no matter the role
- Let them „smell“ the coffee flavor from the design labs at the end of the day
- Let industry and other researchers „hear“ their experiences

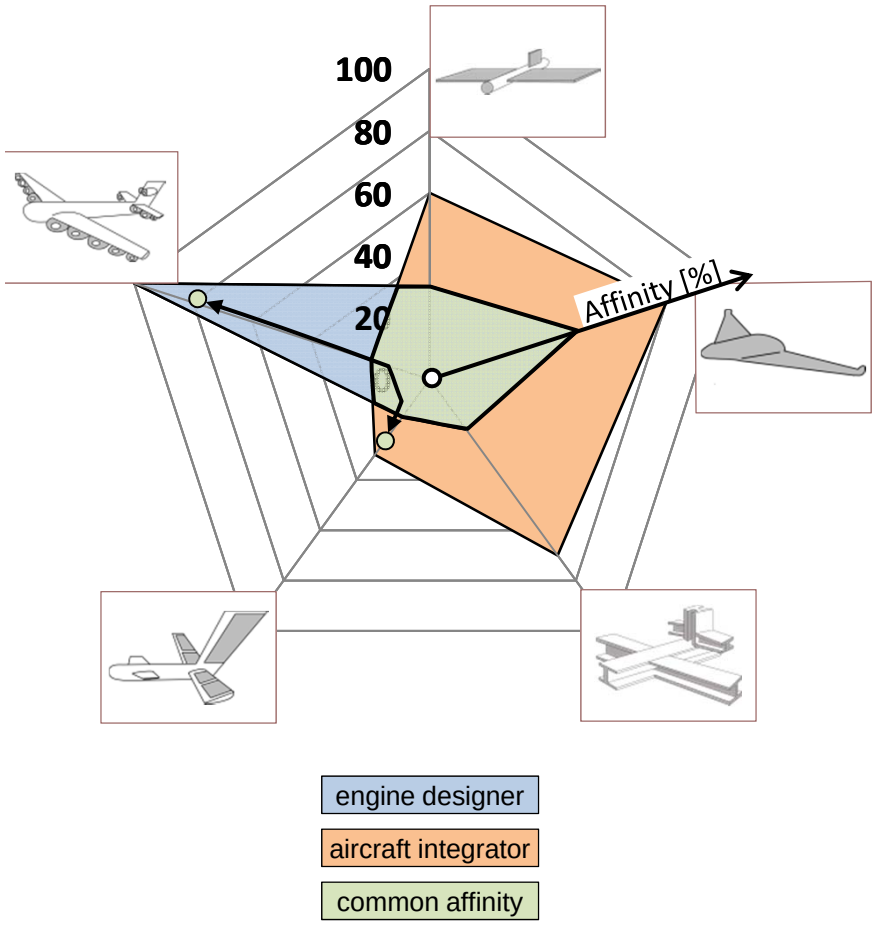
What education can do…



The specialist: change their mindset

- to become part of the chain, specialists have to build proper links
  - → create generally applicable engineering services for integration
    - proper log files (engineers hate this)
    - consensus on interpretation of data
  - → but: welcome stress test for the tool (!)
- specialists need to constantly be aware the effects of their discipline on:
  - other disciplines
  - overall aircraft design
- specialist knowledge is inevitable in:
  - setting up simulation workflows
  - interpreting disciplinary and overall analysis results

The integrator: connector and communicator



The integrator:

- has to build a chain from the available links
- needs capability to ‚glue' specialists together

specialists' need to experience integrators won't eat them

→ intensive communication required with all specialists and the architect

source: Moerland, E., Becker, R. & Nagel, B. CEAS Aeronaut J (2015) 6: 441. doi:10.1007/s13272-015-0153-4

The architect: Mr./Ms. „helicopter view“

- Specialists, integrators are occupied with question:

  are we doing the thing right?

- The architect with the question:

  are we doing the right thing?

→ requires large thrust and getting rid of the „not-invented-here“ syndrome

What education can do practically

Let students gain experience in all roles of collaborative MDO

Provide a large amount of team-oriented design tasks

Let students build their own engineering service
and integrate it in a process integration framework

Educate specialists, but let them integrate in overall design early on

Cross-university student design teams as part of the curriculum (?)

What we can do: educate!

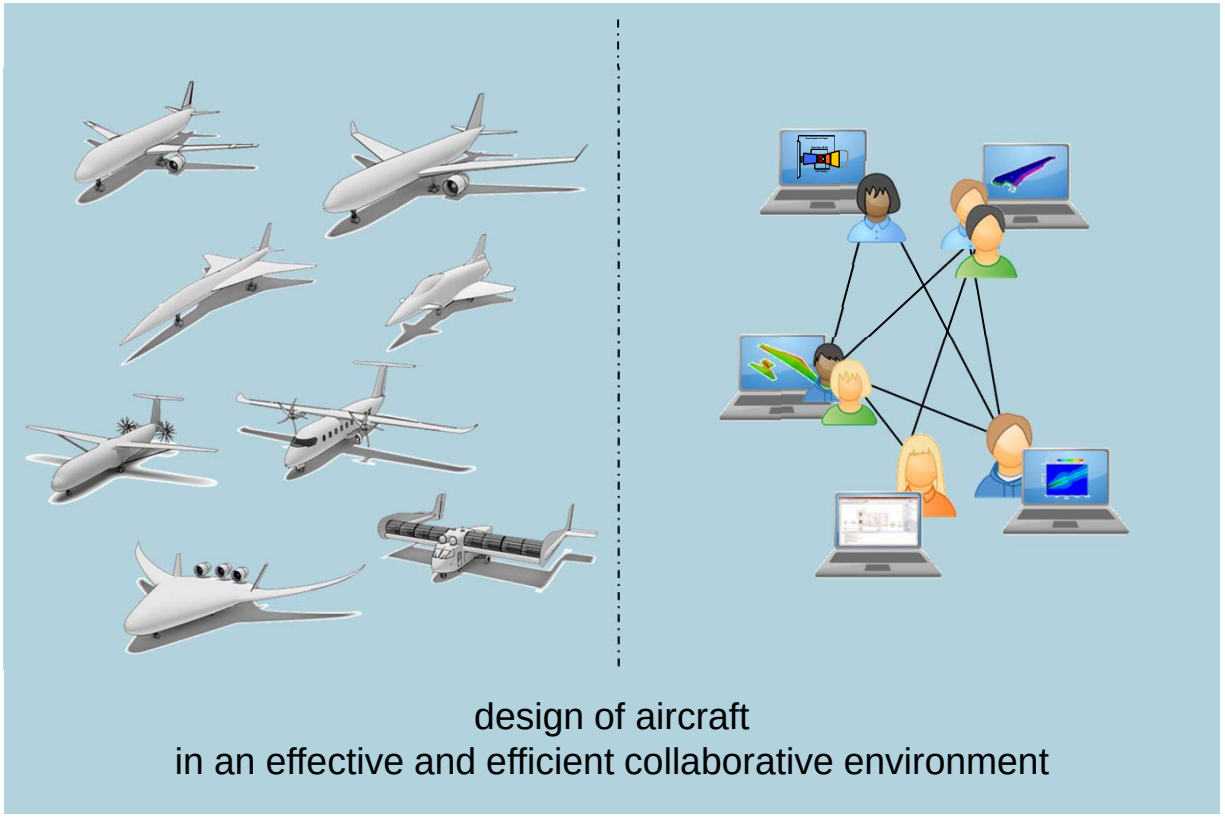
Guide students in performing collaborative MDO

Create open-source collaborative MDO starter package

Host student sessions at conferences

„collaborative MDO“
education session planned
at CEAS 2017

Outlook



design of aircraft
in an effective and efficient collaborative environment

Questions, comments, suggestions

✉ erwin.moerland@dlr.de

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